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PATENT SPECIFICATION

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(21) Application No. 46259/74 (22) Filed 25 Oct. 1974

(44) Complete Specification published 8 Sept. 1976

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(19)

(54) IMPROVEMENTS IN OR RELATING TO STEREOSCOPIC DISPLAY DEVICE

ERRATUM

SPECIFICATION NO 1448520

Page 1, Heading (72) Inventors *delete* JOSEPH HEWIGAN MORRISSY *insert* JOSEPH HOURIGAN MORRISSY

THE PATENT OFFICE
25 May 1977

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If these images are displayed on a common display surface there has to be some form of optical system for separating the images so that neither eye can observe the image appropriate to the other eye. One way of achieving this separation of image involves the use of optical polarising systems.

The two images do not have to be displayed simultaneously because use can be made of the phenomenon of persistence of vision. One way of taking advantage of this phenomenon is to arrange for the two images to be displayed alternately upon the common display surface. Under these circumstances the same display generation apparatus can be used for generating the two images in turn, but this then requires the use of some optical switching element to code the sequential images so that they can be distinguished and separated.

According to the present invention there is provided a stereoscopic image display device in which stereoscopic images are displayed alternately and sequentially on a common surface wherein the stereoscopic images are separated for observation by right and left eyes respectively by an optical system incorporating fixed polarisers acting in conjunction with one or more liquid crystal cells acting as electrically-control-

The stereoscopic display device of Figure 1 uses a cathode ray tube 10 upon which to display stereoscopic images alternately and sequentially. The face plate of the cathode ray tube is covered with a sheet 11 of linearly polarising material. (Alternatively the linearly polarising material may be incorporated in the cathode ray tube faceplate structure.) Placed in front of the linear polariser 11 is a suitably oriented so-called twisted nematic liquid crystal cell 12 having a 90° twist. The display is observed through linearly polarising spectacle elements 13 and 14. The polarisation axes of the elements are at right angles to each other and are arranged so that one element, element 13 say, is aligned with the polariser 11 while the other is crossed.

The cell 12 has a thin layer of a nematic liquid crystal medium, composed for instance of a mixture of cyano-biphenyl hydrocarbon derivatives sandwiched between electroded glass plates forming the major walls of the cell. The inner surface of both walls are treated by a conventional technique for causing the molecules of the liquid crystal medium that are in contact with those surfaces to align themselves in particular orientations with respect to a direction in those surfaces. In order to

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(54) IMPROVEMENTS IN OR RELATING TO STEREOSCOPIC DISPLAY DEVICE

(71) We, STANDARD TELEPHONES AND CABLES LIMITED, a British Company, of 190 Strand, London, W.C.2., England, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

This invention relates to stereoscopic image display devices.

The creation of the illusion of a 3 dimensional image requires the use of two separate 2 dimensional images, one of which is applied only to the left eye while the other is applied only to the right eye. If these images are displayed on a common display surface there has to be some form of optical system for separating the images so that neither eye can observe the image appropriate to the other eye. One way of achieving this separation of image involves the use of optical polarising systems.

The two images do not have to be displayed simultaneously because use can be made of the phenomenon of persistence of vision. One way of taking advantage of this phenomenon is to arrange for the two images to be displayed alternately upon the common display surface. Under these circumstances the same display generation apparatus can be used for generating the two images in turn, but this then requires the use of some optical switching element to code the sequential images so that they can be distinguished and separated.

According to the present invention there is provided a stereoscopic image display device in which stereoscopic images are displayed alternately and sequentially on a common surface wherein the stereoscopic images are separated for observation by right and left eyes respectively by an optical system incorporating fixed polarisers acting in conjunction with one or more liquid crystal cells acting as electrically controllable optically active elements operable at the image alternation frequency.

There follows a description of display devices embodying the invention in preferred forms. The description refers to the accompanying drawings in which:—

Figures 1a and 1b schematically depict a stereoscopic display device displaying left and right eye images respectively, the device employing linear polarisation coding, and

Figures 2a and 2b schematically depict an alternative stereoscopic device displaying left and right eye images respectively, the device employing circular polarisation coding.

The stereoscopic display device of Figure 1 uses a cathode ray tube 10 upon which to display stereoscopic images alternately and sequentially. The face plate of the cathode ray tube is covered with a sheet 11 of linearly polarising material. (Alternatively the linearly polarising material may be incorporated in the cathode ray tube faceplate structure.) Placed in front of the linear polariser 11 is a suitably oriented so-called twisted nematic liquid crystal cell 12 having a 90° twist. The display is observed through linearly polarising spectacle elements 13 and 14. The polarisation axes of the elements are at right angles to each other and are arranged so that one element, element 13 say, is aligned with the polariser 11 while the other is crossed.

The cell 12 has a thin layer of a nematic liquid crystal medium, composed for instance of a mixture of cyano-biphenyl hydrocarbon derivatives sandwiched between electroded glass plates forming the major walls of the cell. The inner surface of both walls are treated by a conventional technique for causing the molecules of the liquid crystal medium that are in contact with those surfaces to align themselves in particular orientations with respect to a direction in those surfaces. In order to

provide the required 90° twist, the plates are assembled so that the alignment direction of one is at right angles to that of the other. The assembly is then mounted so that one of the alignment directions is parallel with the plane of polarisation of the polariser 11.

In the absence of an electric field applied across the cell 12, the liquid crystal is optically active and rotates the plane of polarisation of transmitted light by 90°. This situation is depicted in Figure 1a. The arrows in this Figure depict the planes of polarisation, and from this it can be seen that the image is transmitted to the left eye 15 but not to the right eye 16.

When a suitable electric field is applied across the cell as depicted in Figure 1b this optical activity of the liquid crystal is effectively destroyed. In this condition there is no rotation of the plane of polarisation and hence the image is now presented to the right eye instead of to the left one.

The display device is operated so that the application of the electric field is synchronised with the presentation of alternate images. With a proper choice of frame speed persistence of vision ensures that each image appears continuous in time, and in this way the illusion of a three dimensional image is created.

In a modification of the above described display device (not illustrated) the liquid crystal cell 12 of Figures 1a and 1b is removed and replaced by a liquid crystal cell mounted in front of each spectacle element. The linear polariser 11 may be similarly removed, and replaced with linear polarisers placed in front of the cells.

In the foregoing description the left eye and right eye images have been coded as images that are linearly polarised in mutually perpendicular planes. A modification of this will now be described in which the images are coded as images that are respectively left-handed and right-handed circularly polarised.

Referring to Figures 2a and 2b, the face plate of a cathode ray tube 20 is covered with a sheet 21 of linearly polarising material. Placed in front of the linear polariser 21 is a birefringent quarter-wave retardation plate 27 oriented with respect to the polarisation plane of the linear polariser such that the combination forms a circular polariser. A 90° twisted neumatic liquid crystal cell 22, similar to the cell 12 described above with reference to Figures 1a and 1b, is placed between the linear polariser 21 and the retardation plate 27. This cell has to be similarly oriented with one of its alignment directions parallel with the plane of polarisation of the polariser 21.

Insertion of this cell 22 produces a 90° rotation of the plane of polarisation with the result that the handedness of the circularly polarised light emerging from the retardation plate is reverse. When however a suitable electric field is applied across the cell 22 the 90° rotation is destroyed with the result that the circularly polarised light reverts to its original handedness. With this arrangement the display is observed through circularly polarising spectacle elements 23 and 24 that are left-handed and right-handed respectively.

A further modification of either of the above described stereoscopic display devices incorporating a cathode ray tube covered with a linear polariser involves placing a quarter-wave retardation plate between the face plate and the polariser suitably oriented so that the retardation plate and the polariser function as a circular polariser to ambient light incident upon the face plate. This is effective in blocking the ambient light reflected at the face plate, but has no effect upon the light emitted by the cathode ray tube phosphor.

One application of the invention is in the production of stereoscopic television, another is in the production of stereoscopic radar plots for air traffic controllers. It is to be understood however that the invention is not restricted to cathode ray tube display devices. For instance it may be applied to cine projection display devices in which the images are projected upon a screen. As with the previously described examples the polarisation coding can be performed immediately in front of the display source, in this instance the projector, or it can be performed at the spectacle elements worn by an observer of the display.

The above devices have been described with particular reference to "twisted nematic" liquid crystal cells, but other electrically controllable liquid crystal devices (cholesteric or smectic), or combinations of them, which can rotate plane polarised light or convert left-handed circular or elliptical polarised light to right-handed polarisation, may be used in their place. By way of example a 90° cholesteric twist, analogous to that in a twisted nematic liquid crystal cell may be obtained by adjusting the composition of either a mixture of a nematic plus an optically active material, or of two suitable cholesteric materials of opposite handedness.

WHAT WE CLAIM IS:

1. A stereoscopic image display device in which stereoscopic images are displayed alternately and sequentially on a common surface wherein the stereoscopic images are separated for observation by right and left

eyes respectively by an optical system incorporating fixed polarisers acting in conjunction with one or more liquid crystal cells acting as electrically controllable optically active elements operable at the image alternation frequency.

2. A stereoscopic image display device as claimed in claim 1 wherein the optical system includes first and second polarising parts, the first part including said one or more cells, which first part produces left and right eye images, which are linearly polarised at right angles to each other, which polarised images are analysed by the second part.

3. A stereoscopic image display device as claimed in claim 1 wherein the optical system includes first and second polarising parts, the first part including said one or more cells, which first part produces left and right eye images which are circularly polarised with opposite handedness which polarised images are analysed by the second part.

4. A stereoscopic image display device as claimed in claim 2 or 3 wherein the polarised images are generated by a display device optical source which incorporates said first part and wherein the second part is constituted by spectacle elements to be worn by the or each observer of the display.

5. A stereoscopic image display device as claimed in claim 2 or 3 wherein the cells are incorporated with said second part in spectacle elements to be worn by the or each observer of the display.

6. A stereoscopic image display device as claimed in claim 2 or 3 wherein both said polarising parts are incorporated in spectacle elements to be worn by the or each observer of the display.

7. A stereoscopic image display device as claimed in any preceding claim wherein the or each liquid crystal cell is a 90° twisted nematic liquid crystal cell.

8. A stereoscopic image display device as claimed in any one of claims 1 to 6 wherein the or each liquid cell is a 90° twisted cholesteric liquid crystal cell.

9. A stereoscopic image display device as claimed in any preceding claim wherein the images are projected upon a screen.

10. A stereoscopic image display device as claimed in any preceding claim which device incorporates a cathode ray tube.

11. A stereoscopic image display device substantially as hereinbefore described with reference to Figures 1a and 1b or Figures 2a and 2b of the accompanying drawings.

S. R. CAPSEY,

Chartered Patent Agent,

For the Applicants.

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Fig. 1a.

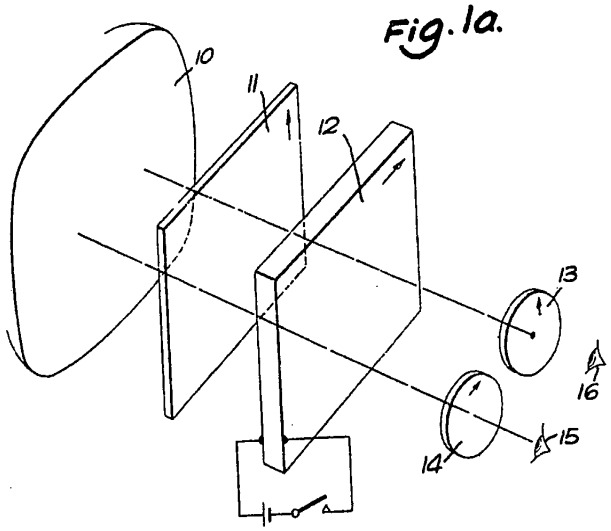
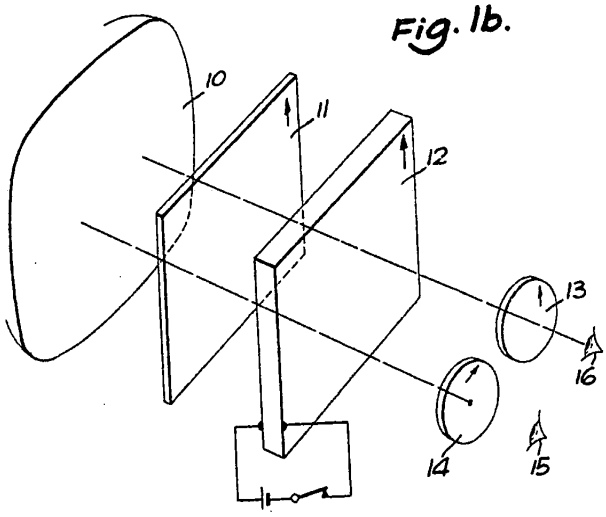


Fig. 1b.



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Sheet 2

Fig. 2a.

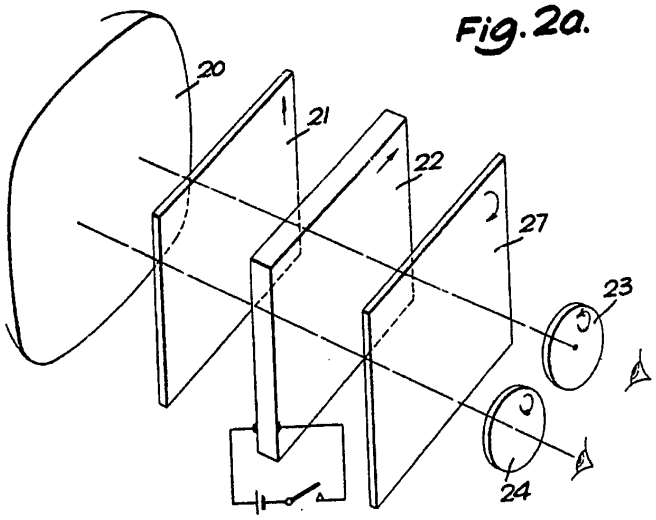

Fig. 2b.